Unique, Closed Weapons Systems Designs

- **Cost Too Much to Develop**
- **Cost Too Much to Support**
- **Cost Too Much to Modify**
- **Can Not Readily Employ New Technologies**
- **Inter-operation Is Less Than Desirable**
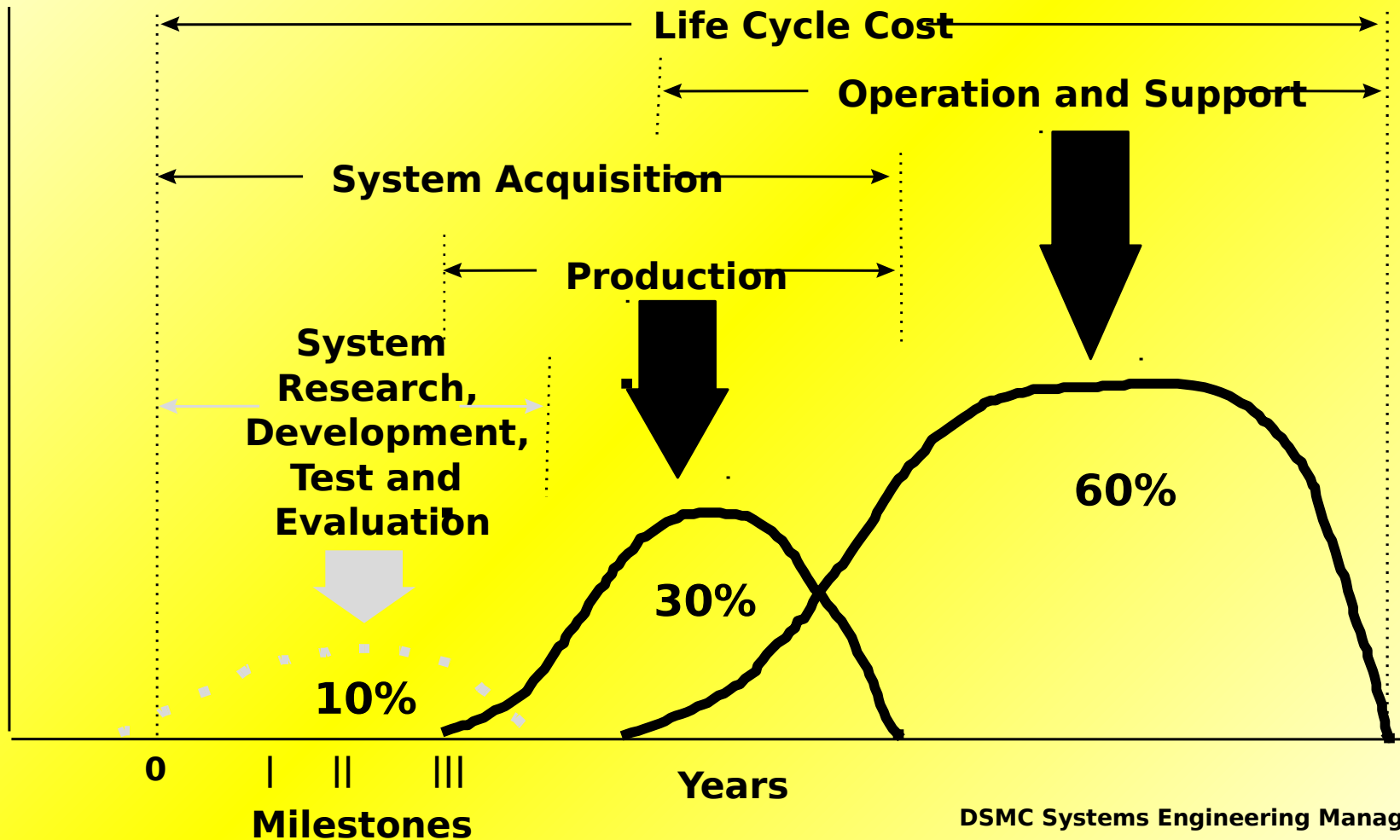
Longer Weapon System Life

Reduced DOD Budget

Increased Dominance of Commercial Market

Shortened Technology Cycle Time

Life Cycle Costs

Life Cycle Cost

Operation and Support

System Acquisition

Production

System Research, Development, Test and Evaluation

60%

30%

10%

0 | || |||

Years

Milestones

What Is an Open System Approach?

The open system approach is an integrated business and technical strategy to:

- **choose commercially supported specifications and standards for selected system interfaces (external, internal, functional and physical), products, practices and tools, and**

- **build systems based on modular**

Typical Open Interface Examples
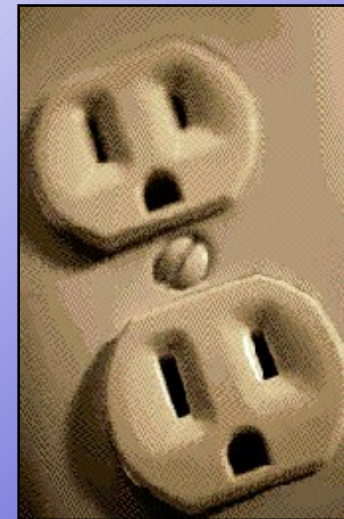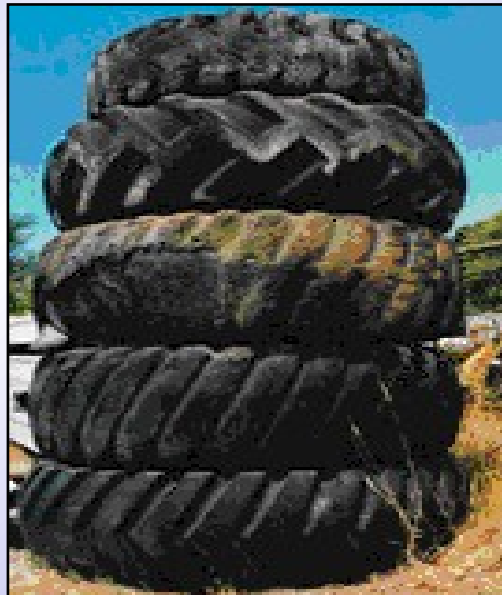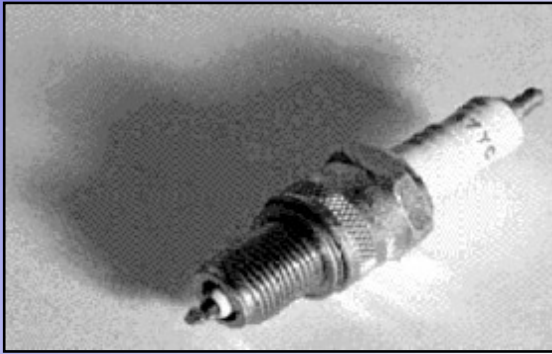
Business and Technical Approach

It is a business approach to leverage use of commercial products that directs resources to a more intensive preliminary design effort to result in a lifecycle cost reduction. As a business approach it supports the DOD policy initiatives of CAIV, increased competition, and use of commercial products.

It is a technical approach that emphasizes systems engineering, interface control, modular design, and design for upgrade. As a technical approach it supports the engineering goals of design flexibility, risk reduction, configuration control, long term supportability, and enhanced utility.

The Open Systems Approach Makes Sense Whether You are a Manager, Engineer, Logistician, Comptroller, or Contracting Officer

Open Systems Benefits
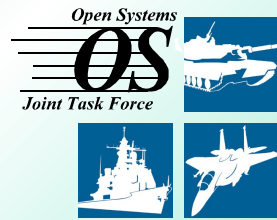
Easier Technology Insertion

Systems Fielded Faster

Improved Intra- & Interoperability

State-of-the-Art Systems

Increased Competition

Improved Operational Capability

Better Performance

Improved Support

Reduced Life Cycle Costs

Relationship to Acquisition Reform

Objectives:
Reduced Cycle Time
Lower Costs

Acquisition Reform

Cost as an Independent Variable

Trade Performance and Schedule for Lower Costs

Performance SPECs

State requirements in terms of needs, not designs

Clear Accountability in Design

Government Controls Performance -- Contractor Designs the Solutions.

Non-Developmental and Commercial Items

Use Existing Technology and Products, If Applicable

OPEN SYSTEMS IS AN ENABLER

Horizontal Technology Insertion

Evolutionary Acquisition

Modernization Through Spares

Program Management Impacts

Impacts

Planning

    - Up-front Costs

    - Early Schedule Slips

    - Planning and Direction

Risk Management

  - Metrics

Modeling and Simulation

Configuration Management

Negative COTS Impact - Military Environment

Planning

"What decisions have been made to ensure that the widest range of suppliers will have the opportunity to offer their products throughout the program life cycle?"

Schedule -

More Time in Systems Definition and Preliminary Design, Less in Detail Design and Production.

Cost -

More Cost in Design and Less in Lifecycle

Risk Management -

Leveraging Commercial Practice

- **- Design Flexibility To Control Technical Risk**

  - **- Compartmentize Risk Areas**

  - **- Multiple Sources = Multiple Solutions**

  - **- Variety of Suitable Commercial Products**

- **- Cost Control**

  - **- Unit Cost Estimates (Commercial Products)**

  - **- Design Change Costs (Limit Unforeseen Impacts)**

  - **- LCC Estimates (Availability and**

Risk Management - New Concerns

-**Reliance on Commercial Items Over Which the Government Has No Configuration Control.** Mitigate Through Use of Standards That Provide the Widest Commercial Base and Development of a Thorough Conformance Management Process,

-**Reliance on Standards That May Also Change.** Mitigate Through Government Involvement With Standards Development and a Conformance Management Process That Emphasizes Standards Conformance As Well As Product Conformance,

-**Selection of the Wrong Standards.** Mitigate Through Careful Market Analysis. Where the Choice Is Close Between Competing Standards, Mitigate Through Design Consideration of the Consequences of Future Upgrade to Alternative Standards.

Metrics

What to Measure? On Program Level:

Interface Control - Number or Rate of Interface Changes.

Conformance - Number and Rate of Conformance Items Demonstrated.

Openness - Number of Configuration Items (CIs) Governed by Open Interface Standards and/or Specifications.

Have a Measurement Process. Continually Assess the Measurement Process As Well As the Project Performance.

Modeling and Simulation

Constructive - Use Automated Tools to:

- Control and Document Interface Requirements.

- Support Functional Partitioning and Modular Design

- Help Translate Interface Requirements Into Component Requirements.

Virtual - Use Virtual Tools to Analyze and Verify Interoperability, Intra-operability of Major Subsystems, Man-machine Interface, and Software/hardware Interface.

Configuration Management

Enhanced Interface Control.

Control of Preliminary Design Level Performance Specifications

Detail Design Is Under Vendor Control - Details Not Important below "Atomic" Level If Product Is Conforming

Formal Conformance Management in Place of Associated Detail Design Effort

Military Environment

- Military Requirements Traded to Enhance COTS Use

- Commercial Products Come in a Variety of Durability (Some Meet Military requirements.)

- Interface Designs to Protect or Mod COTS, Such As:

HI Shock

Salt Environment

Temperature Extremes

EMI/EMP

Management Considerations

Technical Support to Milestone Decision and PPBS

Tech Review Exit Criteria

Required Architectures Complete

Interfaces Under Control and Driving Component Specifications

Conformance Issues Resolved

Level and Degree of Openness Appropriate

SE Support to Program Management Decision Making

Successful Completion of Exit Criteria at Review

Technology Development and Baselines Sufficient to Proceed

Standards Identified (Appropriate for Level of Development)

Conforming Implementation Products Identified (Appropriate for Level of Development)

No Outstanding OS Technical Issues

Budget Issues

Identify Added Design Activity - Market Survey, Interface Management, Conformance Management.

Identify Additional Test Requirements - Conformance of Products and Updated Standards.

Identify Government and Contractor Training Expenses.

Identify Potential Savings, If Any, for Detail Design Effort.

Identify Potential Savings, If Any, for Unit Cost

Program Impacts Summary

More Time in Systems Definition and Preliminary Design, Less in Detail Design and Production.

More Cost in Design and Less in Lifecycle.

Use the Open System Approach to Help Control Risk and Cost

Use the Open System Approach to Plan for System Upgrade Capability

Contractual Impact

Contractual Impact

RFP Section C

Source Selection and Sections L&M

Contract Management

Acquisition Strategy Should Motivate Designer to Achieve A Practical Open System

Tasking The Contractor - SOW

Statement of Work (SOW) Is a Task Statement Derived From the Program WBS That Forms Section C of the Contract.

Basic Requirement: The contractor shall make maximum use of the open systems design approach to provide flexible interfaces and maximum interoperability, optimum use of commercial competitive products, and enhanced system capacity for future upgrade.

Specific Example : NSSN SOW

New Attack Submarine SOW Open Systems Example/1

3.1.5   Open System Standards.

3.3.1.5.1   Baseline Standards. The Contractor shall use the baseline standards identified in the System Specification for all newly developed hardware and software and for Commercial Off-the-Shelf (COTS) and other Non-developmental Items (NDI) where possible. For NDI which will not conform to the baseline standards, the Contractor shall document the method by which the item will migrate to the open system baseline standards in the SEMP. The Contractor shall document the process for evaluating baseline standards for use, defining profiles, evaluating new and Contractor unique profiles, and updating profiles in the SEMP. The contractor shall develop profiles [ELIN E004] which identify a complete and coherent subset of these baseline standards that support portability, interoperability, maintainability, vendor independence, technology insertion, compatibility with other products, reusability, scalability, and improved user productivity. It is specifically required that all profiles support vendor independent implementations of the components. The contractor shall provide evidence that all profiles proposed are not proprietary, and support vendor independent solutions, as well as support the requirements identified above.

3.3.1.5.2 Open System Performance Evaluation. The Contractor shall document the criteria for evaluating open system performance in the SEMP. The Contractor shall consider, as a minimum, portability, interoperability, maintainability, vendor independence, technology insertion, compatibility with other products, reusability, scalability, and improved user productivity as candidate criteria. The Contractor shall continually evaluate products through market analyses and trade-off studies in accordance with the approved SEMP.

3.3.1.5.3 Implementation Conformance. The Contractor shall validate implementation conformance for all products proposed as meeting the selected profiles by providing documented proof of conformance [ELIN E005]. Where no documentation exists to document implementation conformance, i.e., for legacy items or new technologies, the Contractor shall submit the product as a Critical Item, as described in section 3.4 of Appendix D to the SOW.

AAAV SOW Open Systems Example

- **[3.01.01] Integration & Assembly. The contractor shall employ an Integrated Product and Process Development (IPPD) methodology in its design, integration, and assembly of the AAAV(P) and AAAV(C)/(CP). The contractor shall ensure this methodology includes integration of engineering specialties and management of a totally integrated effort of design engineering, specialty engineering, test engineering, and production engineering to ensure their influence on the design. The contractor shall ensure the timely and appropriate intermeshing of these engineering efforts and disciplines such as: reliability, maintainability, logistics engineering, human factors, system safety, health hazards, environmental considerations, value engineering, standardization, transportability, etc. to ensure their influence on decisions, trade studies, and analyses. The contractor shall develop the AAAV designs with an open architecture that maximizes ease of subsystem and component changes, upgrades and replacement while minimizing vehicle interface changes. This open architecture concept shall especially be employed for subsystems and components that can be expected to change over the life of AAAV and for high cost subsystems where unit cost and operations and support costs could be reduced by replacing high cost subsystems with lower cost subsystems or by opening competition between multiple sources of high cost subsystems. The open architecture concept shall be incorporated throughout the AAAV design. The contractor shall demonstrate how the following AAAV subsystems and their vehicle interfaces incorporate the open architecture concept during appropriate IPT meetings and at each ISR:**
  - **· Engine**
  - **· Fire Control**
  - **· Automotive Drive Train**
  - **· Suspension System**

- **· Marine Drive Train**
- **· Controls and Displays**
- **· Turret Assembly**

Tasking The Contractor - SOO

Statement Of Objectives (SOO) Is 1-2 Page Statement of Government's Objectives. Presented to Offerors in Solicitation. Usually Supplemented With Draft Spec, ORD, Draft SOW or Similar. Contractor Writes SOW As Part of Proposal.

"An open system approach to design is desired to provide for flexible interface and maximum interoperability, optimum use of commercial competitive products, and enhanced system capacity for future upgrade."

Source Selection and Sections L&M

- Sections L & M Critical to Obtaining an Open Systems Approach Especially When Using a SOO in Section C,
- Can Tell the Contractor What Is Important *Without Actually Specifying It*, and
- Offeror Has to Respond Favorably to Get the Contract.

Focus: Written Such That the Government Evaluators Can Assess the Offerors' Understanding and Capabilities Relating to Open System Design.

Source Selection and Sections L&M

Section L

The description of the systems engineering management process should describe the methods by which an open system design approach will be used to provide flexible interfaces and maximize use of commercial competitive products to enhance system capacity for future upgrade.

Section M

Application of the Open System Design Approach: The government will evaluate the following in descending order of importance:_

- How well the contractor identifies a process that will identify and control interface requirements.

- The continuity between the configuration management and interface management efforts.

- The adequacy of the metrics and feedback system is designed to manage the risk associated with using an open systems concept and retaining flexibility of the system."

Source Selection and Sections L&M

Section M Category	Evaluation Criteria
1. Identification and control of interfaces:	1.a. Are interface control products, such as, technical architecture, interface architectures, ICDs, etc. sho milestone deliverables or addressed in SE exit criteria?
	1.b. Is the interface identification method(s) sufficient to identify and assess all functional interfaces betw configuration items, subsystems and external interfacing systems?
	1.c. Is the interface identification method(s) sufficient to identify and assess all physical interfaces betwe configuration items, subsystems and external interfacing systems?
	1d. What is the level of risk associated with the management of interface requirements? ? Is it an accept
	1.e. Is the proposed process adequate for identifying existing commercial interfaces to determine compat the system? Is the proposed process adequate for identifying consensus based industry standards that v achieve this?
	1.f Does the management process address how potential competitive commercial solutions are judged to conforming? What is the risk associated with this method? Will it provide commercial components that v work in the rigors of service?
2. Continuity between configuration management and interface management:	2a. Do the processes reflect adequate coordination capability to ensure that changes to one interface res compatible change to its matching interface? Does the management process address how conformance is identified, assessed, and controlled?
	2b. Do the management processes reflect adequate administrative control of the configuration process t adequate documentation and dissemination of developed interfaces? Do the processes result in assuranc interpretations of interface requirements are coordinated between interfacing configuration developmen
	2c. Does the organizational structure ensure integration of interface development with appropriate config management?
	2.d. Does the proposal show adequate understanding and capability to assure that conformance testing v adequately prepared for and accomplished?
3. Metrics and feedback:	3.a. Can the metrics chosen be used to identify and retain an open systems environment and interface fle the chosen metrics reflect appropriate measurement criteria for tracking and managing interface and con control?
	3.b. Are the metrics comprehensive and balanced?
	3.c. Is the description of the feedback system clear? Will it provide useful information to the government manner?
	3d. Will this feedback system be useful for managing risk associated with using an open systems concep

Contract Management

Tracking Progress

Metrics

- Government or Contractor Generated

- Measure Interface Design and Conformance Issues

- Training, Available Expertise

Award Fee

- Award Fee Allows for Necessary Flexibility

- May Impact IPTs

Integrated Teams (IPTs)

- Joint Government and Contractor Assessment

- Most Effective Way to Insure OS Is Being

Contracts

Summary

Use Performance Based Task Statements in the Contract

Use the Contractor's Approach to Open System Design as an Evaluation Factor

Use Metrics, Award Fees, and IPTs To Track Contractor Progress

Testing
Impact

Testing Impact

Conformance Testing

Testing Standards

Testing Components

Operational Testing

Commercial Availability
Balancing Operational Requirement

Every Requirement Must Be Verifiable!

Conformance Testing

Conformance Management Should Include Both Implementation and Applications Conformance Testing.

The Degree to Which Open Systems Benefits Can Be Achieved Will Depend on How Well the Product Design Conforms to Selected Standards

Use Completely Defined Interface Profiles to Allow Vendors to Build and Designers to Use Standards-based Components.

Candidate Components Should Be Tested Against Detailed System Profiles to Ensure Component Conformance.

Testing Summary

Conformance Testing Requires Both Testing Standards and Components

Operational Testing Requires Balancing Operational Requirements against solutions based on Commercial Availability

Logistics Impact

Logistic Impact/1

Time and Cost to Upgrade a System Is Reduced.
- Defense systems average 40 year life span,
- Upgrade likely due to component obsolescence, threat increase, or technology push.
- Commercial products designed for shorter life,
- Original commercial components will not necessarily be available throughout a military system's lifecycle.
- Open system design eases replacing the component, reducing upgrade cost and schedule, which reduces operational impact.

Use of Competitive Products to Support the System
- Reduced cost
- Improved component and parts availability

Logistic Impact/2

Conformance Management Is a Lifecycle Process

- Replacement of components must be more

controlled
- Government has to control the system configuration without controlling the detail component configuration.
- Component will come from multiple sources, all with different detail configurations.
- Commercial configuration control without regard to the needs of the government's systems.
- Must use performance and interface based specifications to assure service equivalent to originally approved
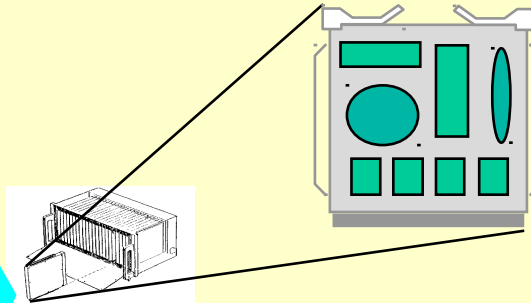
Module Replacement or Upgrade
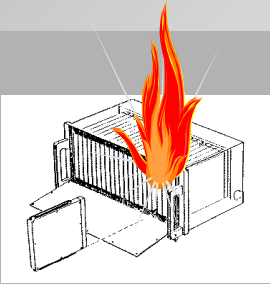
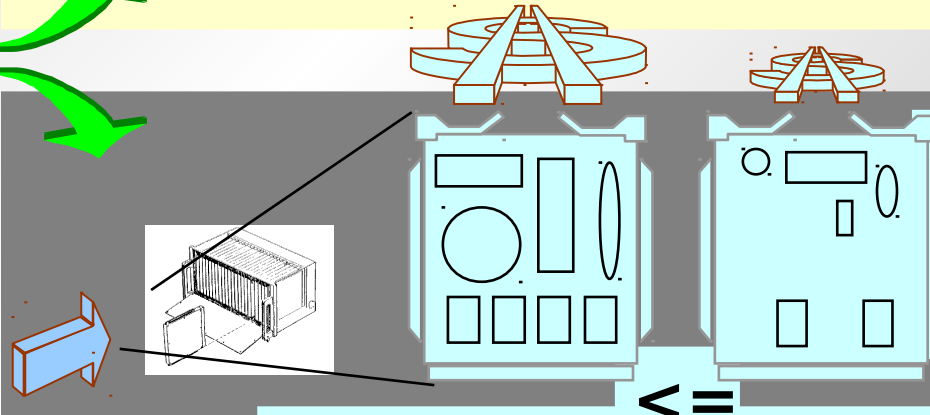**Module Fails**
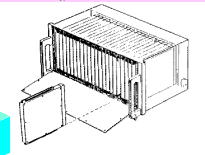
Remove Module

**Without OSA
Must replace with identical module**
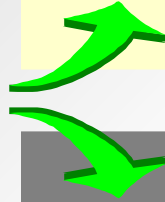
**With OSA
May replace with identical
OR
*other configuration***

<=

- **Module interface rigorously controlled**
  - » **New interface must be backward compatible**
- **Numerous operational configurations possible**
  - » **Not all possible configurations explicitly tested**

Impact Areas

Part Procurement

Modernization Through Spares

Product Upgrade

Conformance Management and Testing

Logistic Benefits

Easier to Repair Or Modify

Part Replacement -

   Multiple Sources

   Commercial Sources

Modernization Through Spares -

   Upgraded Commercial Components

   Based on Open Standards

Logistic Benefits

Product Upgrade -

    Firewall Modularity

    Designed for Upgrade

Conformance Management and Testing -

    Standardized Product Acceptance Requirements

Logistic Problems

Conformance Management and Testing -

   No Configuration Control

   No Control Over Standard

   Durability

   Production Quality

Logistic Problems

No Configuration Control

Potential Approach:

   - Conformance Testing,

   - Certification of Prior Conformance,

   - Qualified Products List.

No Control Over Standard

Potential Approach:

   - Monitor and Analyze Changes in Standards and Technology (Tech Changes Lead to Standards Change.)
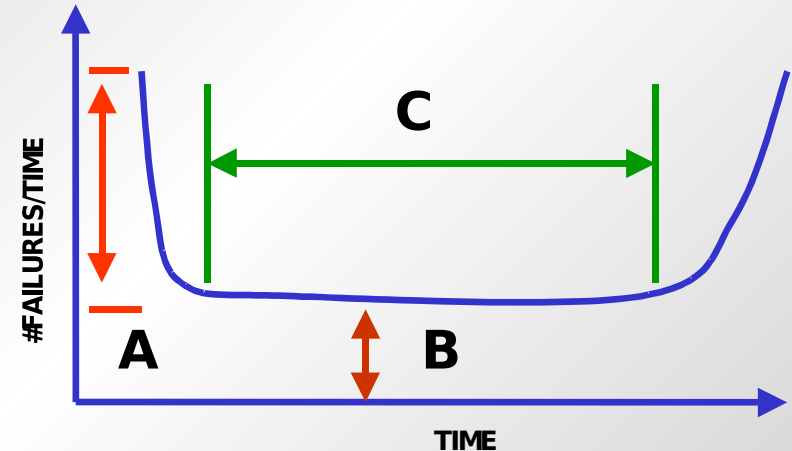
   - Conformance Testing of Revised Standards

   - GOVERNMENT INVOLVEMENT IN STANDARDS GENERATION

Logistic Problems

Production Quality

Durability

With Multiple Commercial Sources How Do You Determine the Form of the Bath Tub Curve for each?

A - Infant Mortality: How Many Will Fail Early Because of Production Quality? Potential Approach: Statistical Testing of Production.

B - Failure Rate: High Failure Rate Usually Indicates Design Is Marginal for Application. Potential Approach: Accelerated Durability Testing With Overload Sensitivity Provisions.

C - Average Life: Life Is Usually Designed-in Based on Performance Required. Potential Approach: Accelerated Durability Testing With Overload Sensitivity Provisions.

Big Problem: Durability (Endurance) Tests Can Be Are Expensive!

Logistic Problems

Due to Cost of Conformance Do Risk Management:

   Prioritize Components

   Fully Test All Safety and Critical Parts

   Obtain Industry Certification or Limited Statistical Testing for Less Than Critical.

View Cost of Part in Relationship to System and Consequences to System.

Logistics Summary

Time and Cost to Upgrade a System Is Reduced.

Competitive Products Are Used to Support the System.

Conformance Management Is a Lifecycle Process.

Conformance Management Problems Include No Configuration Control Over the Component, No Control Over Standard, and No Control Over Design or Production Quality.

Risk Management: Prioritize Components, Fully Test All Safety and Critical Parts, Obtain Industry Certification or Limited Statistical Testing for Less Than Critical.

Legacy Systems

Legacy Systems

Upgrading Older Closed Systems to Open Systems

Cost Effectiveness -

Use cost effectiveness analysis to determine if migration is appropriate.

Migration Process

Compartmentize the design and incrementally transition to open design.
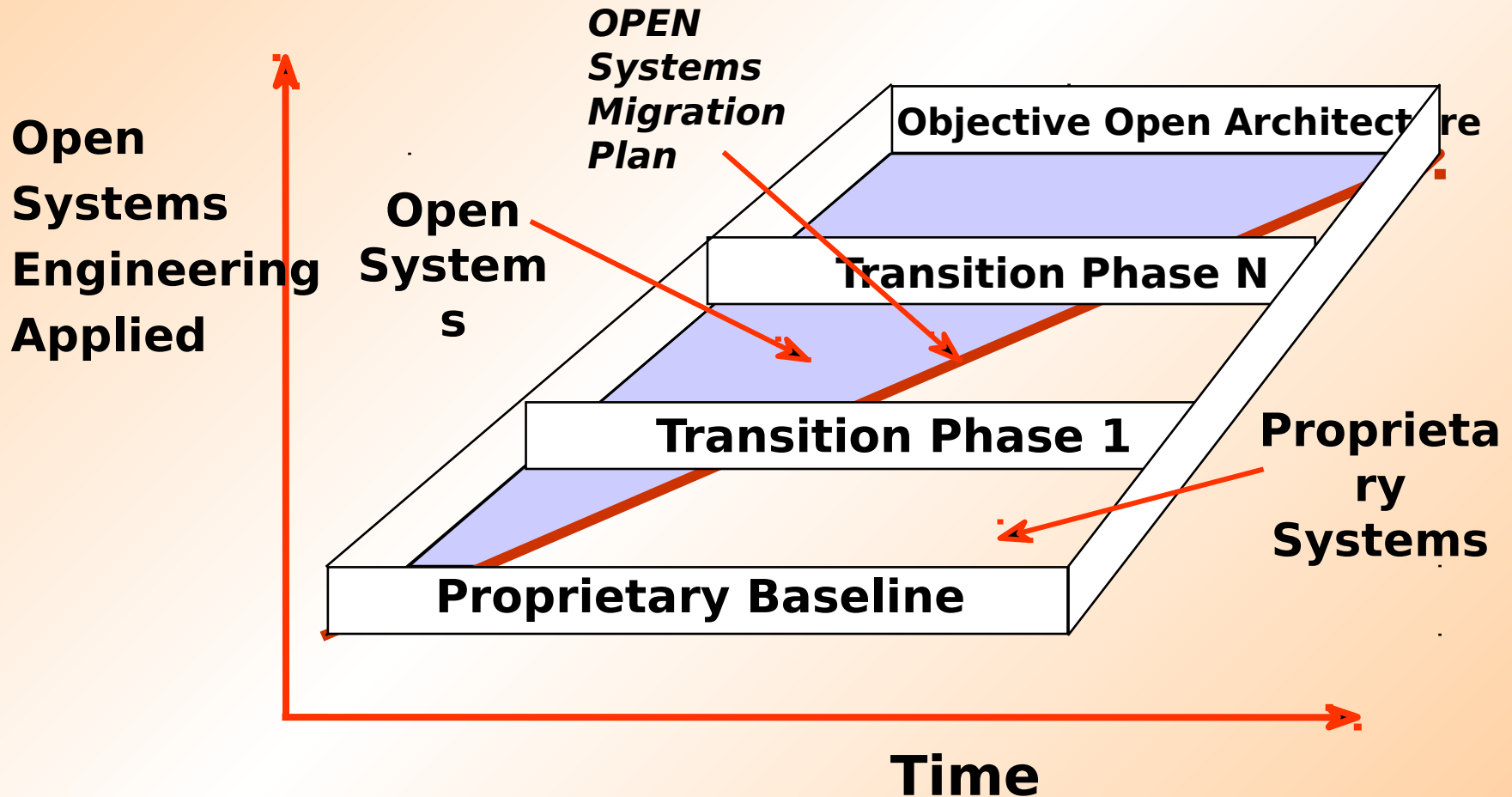
Cost Effectiveness

- **Cost of Maintaining Current System**
- **Transition Cost vs. Open Cost/Benefit**
- **Modularity of Component**
- **Difficulty or Ease of Transition**

Migration Process

- **Develop a phased transition plan reflecting your business priorities**
- **Categorize components, functional domains, and/or operational domains for criticality, modularity, cost of maintaining, performance,...**
- **Evaluate components as to how they will transition**
- **Aggressively Manage Transition**

Migration Process

Open Systems Engineering Applied

OPEN Systems Migration Plan

Open Systems

Objective Open Architecture

Transition Phase N

Transition Phase 1

Proprietary Baseline

Proprietary Systems

Time

Migration Summary

Cost Effectiveness -

Use Cost Effectiveness Analysis to Determine If Migration Is Appropriate.

Migration Process -

Compartmentize the Design and Incrementally Transition to Open Design.

LESSON SUMMARY

- **Open System Approach Emphasizes**

    - **Modular Interfaces and Multiple Design Solutions,**

    - **Maximum Interoperability,**

    - **Use of Open Standards and Commercial Competitive Products,**

    - **Enhanced Capacity for Future Upgrade.**

- **Business and Technical Approach**

    - **Business Establishes the Need and Availability**

    - **Technical Supplies the Means**

- **Associated with Clear Lifecycle Performance, Cost, and Schedule Benefits**

- **Acquisition Reform Enabler**

BACKUP SLIDES

Management Considerations for SE Planning

- **Process for Evaluating Open Systems Baseline Standards, Defining and Updating Profiles, Evaluating New and Contractor/vendor Unique Profiles**

- **Methods, Tools, Procedures, and Means to Be Used to Achieve Open Systems Benefits Such As Portability, Interoperability, Technology Insertion, Vendor Independence, Scalability, and Commercial Product Based Maintainability**

- **Process for Validating Implementation Conformance to Selected Profiles**

- **Process for Managing Application Conformance to Selected Profiles**

- **Training in OSEM, Conformance Management, Use of Profiles.**

**Based on N. Kowalski, "Key Engineering Management
to Achieving an Open System in a DoD Environment**

Systems Engineering Planning Tailoring for OS

SEMP Paragraph	Aircraft Specific Template Information
Systems Engineering Process	**Identify tasks and accomplishment criteria which coordinate this specific effort with the overall Aircraft Open System Architecture Approach**
System Engineering Process Planning	**Identify open system architecture related objectives and deliverables define how program interfaces into the standards catalog**
Requirements Analysis	**Identify interface and feedback path to requirements and constraints specification, detail the verification, deployment, support, and training requirements**
Synthesis	**Address how open system architecture standards and COTS products should be selected from catalog to synthesize specific architecture**
Systems Analysis and Control	**Identify standard simulation and specification tools, trade requirements and criteria for assessing applicability of open system architecture standards. and COTS products** **Identify risk management requirements**
Control	**Identify coordination points to Aircraft program office.**
Transitioning Critical Technologies	**Identify requirements for merging critical technologies and new standards into standards catalog compliant form**
Integration of Systems Engineering Effort	**Identify various inputs to the effort and how this effort should be coordinated with other related Aircraft activities through IPTs.**

Open Systems Test Challenges

- **Achieving high fault detection/isolation in open systems <u>major</u>challenge**
  - **COTS-based hardware has inherently less diagnostic test capability than our custom implementations**
    - » **Most COTS suppliers adhere to IEEE Std. 1149.1 but still only provide ~80% BIT fault coverage**
    - » **Doesn't usually meet DoD requirements**
  - **Hard to accurately evaluate fault coverage and find "voids**
    - » **Lack of rights/access to COTS design data**
    - » **Inconsistent support from vendors**
  - **Lack of widely accepted standards at the system-level**
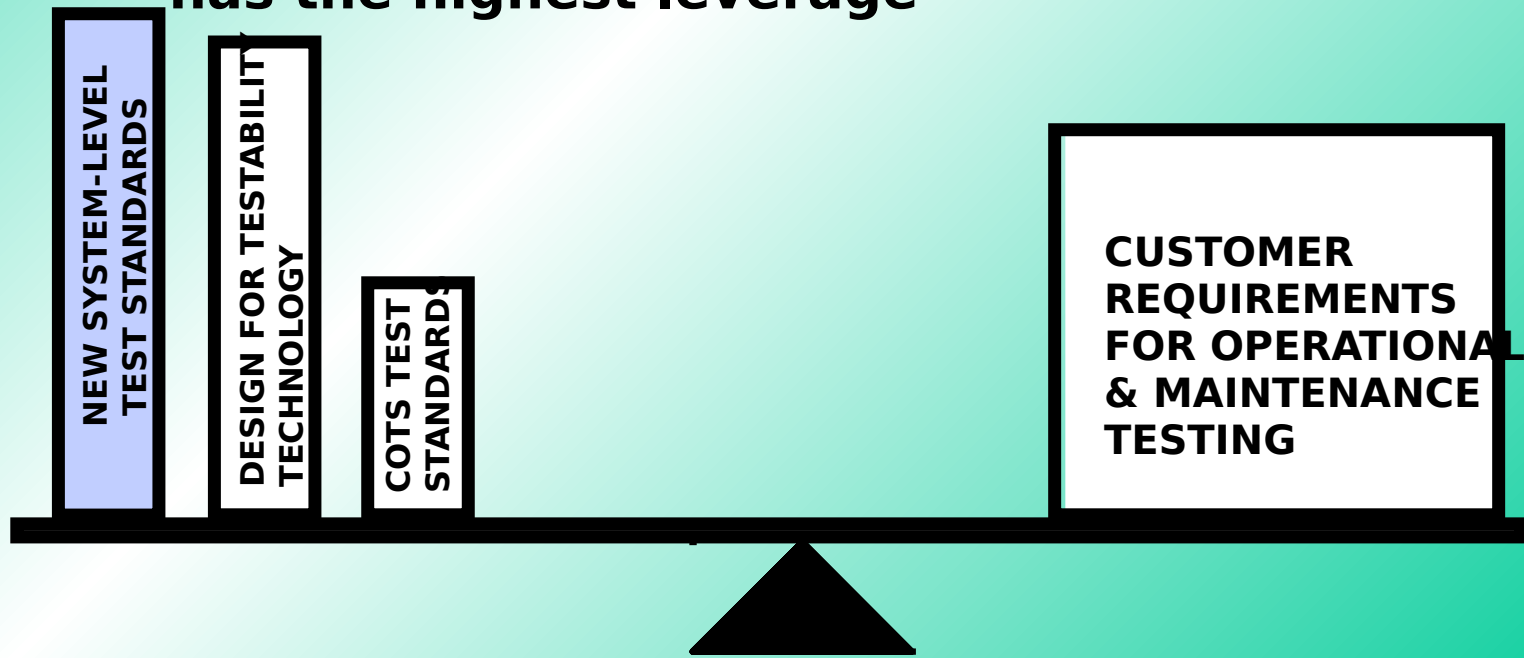
Example: Computer Resources

Solutions for Testing of COTS-based Systems

PROBLEM	SOLUTION	APPROACH
Cannot quantify testability numbers (coverage, time, etc.)	Assess each Vendor's Built-In Test (BIT)	Develop a COTS BIT evaluation process
Minimal test verticality	Reuse component & board tests at system level	Integrate the IEEE 1149.1 and 1149.5 test busses
Minimal test horizontality	Reuse the same tests at all Maintenance sites (one-level maintenance)	Develop standards to facilitate test suite deployment to all maintenance sites
Weak fault management system	Integrate the hardware and software functions	Develop a portable fault management system

Balancing an Open Systems Testing Environment

- **COTS advantages are lessened due to military requirements for high fault coverage and isolation**

- **Standardizing system-level testability techniques has the highest leverage**

NEW SYSTEM-LEVEL TEST STANDARDS

DESIGN FOR TESTABILITY TECHNOLOGY

COTS TEST STANDARDS

CUSTOMER REQUIREMENTS FOR OPERATIONAL & MAINTENANCE TESTING

Example: Computer Resources
Opportunities for Improvement

- **COTS Vendors, Military Contractors, and Mili[tary] Customers all need more information about [open] systems testing**
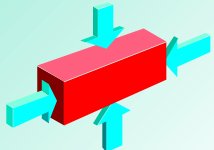
  – **Develop approach to determine real system FD/FI[...]**

  – **Work towards industry adoption of standards for [...] implementation at unit and system level**

  – **Produce an "Open Systems Testability Guidebook[" that] can be used by everyone**

  – **Create an architecture for an Open Autonomous T[est] Controller to enable test verticality/horizontality and a more cost effective fault management system**
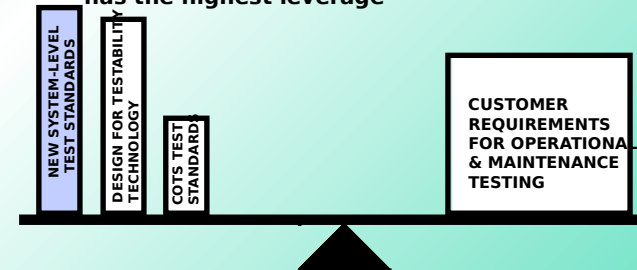
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DESIGN FOR TESTABILITY TECHNOLOGY

COTS TEST STANDARDS

CUSTOMER REQUIREMENTS FOR OPERATIONAL & MAINTENANCE TESTING

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Opportunities for Improvement

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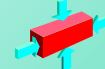 - **Develop approach to determine real system FD/FI**
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